Aug. 9, 1955 E. A. ZEITLIN 2,715,007

GIMBAL MOUNTING

Filed July 31, 1953 2 Sheets-Sheet 1

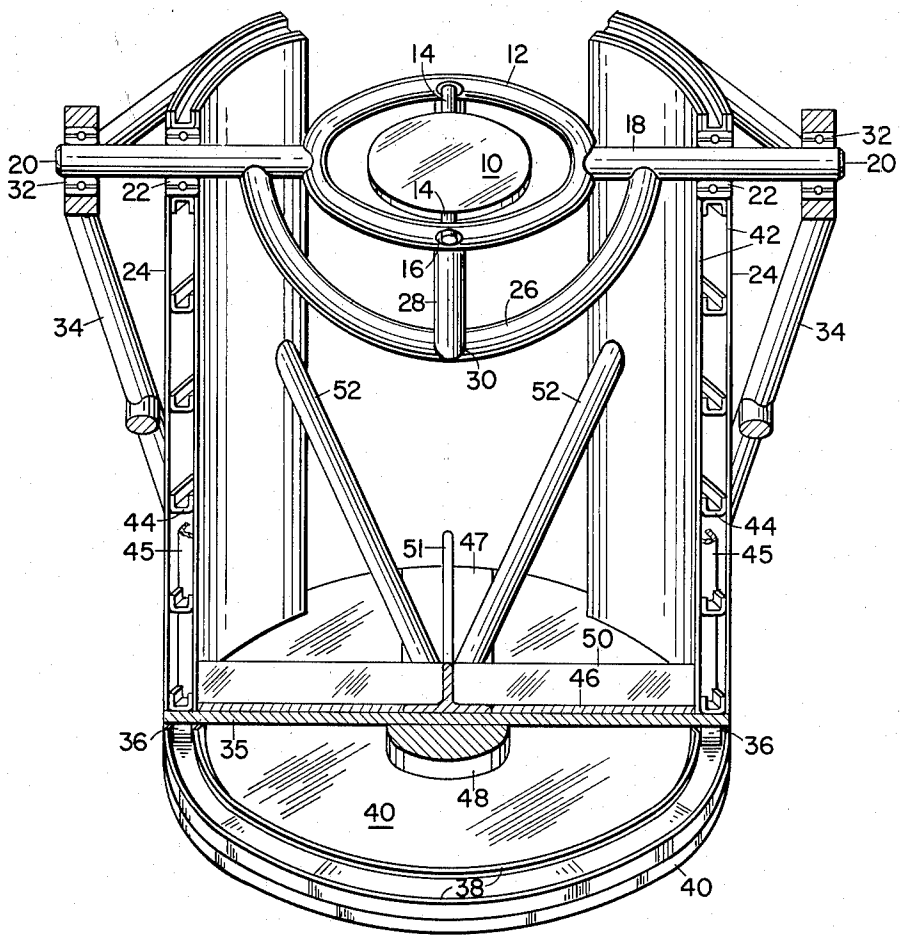


Fig. 1

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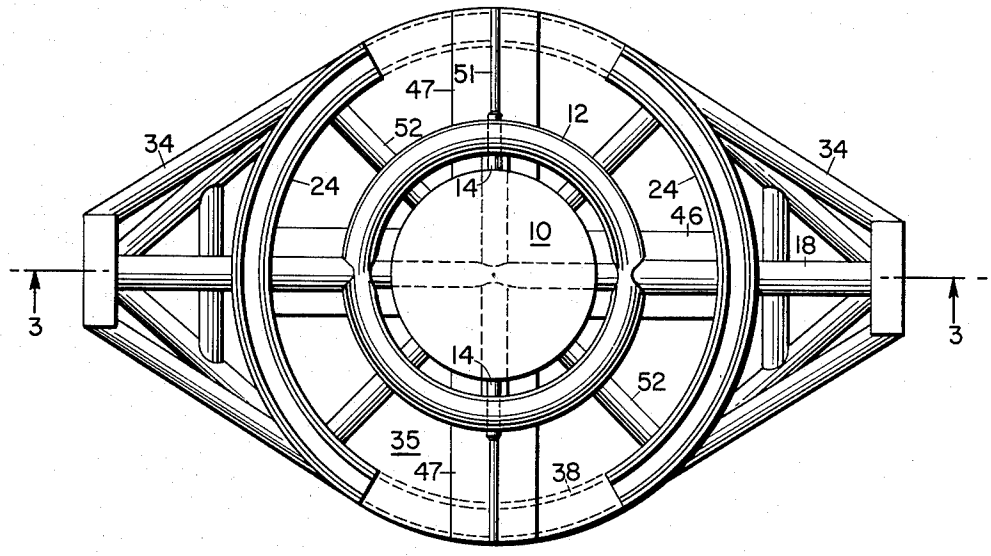


Fig. 2

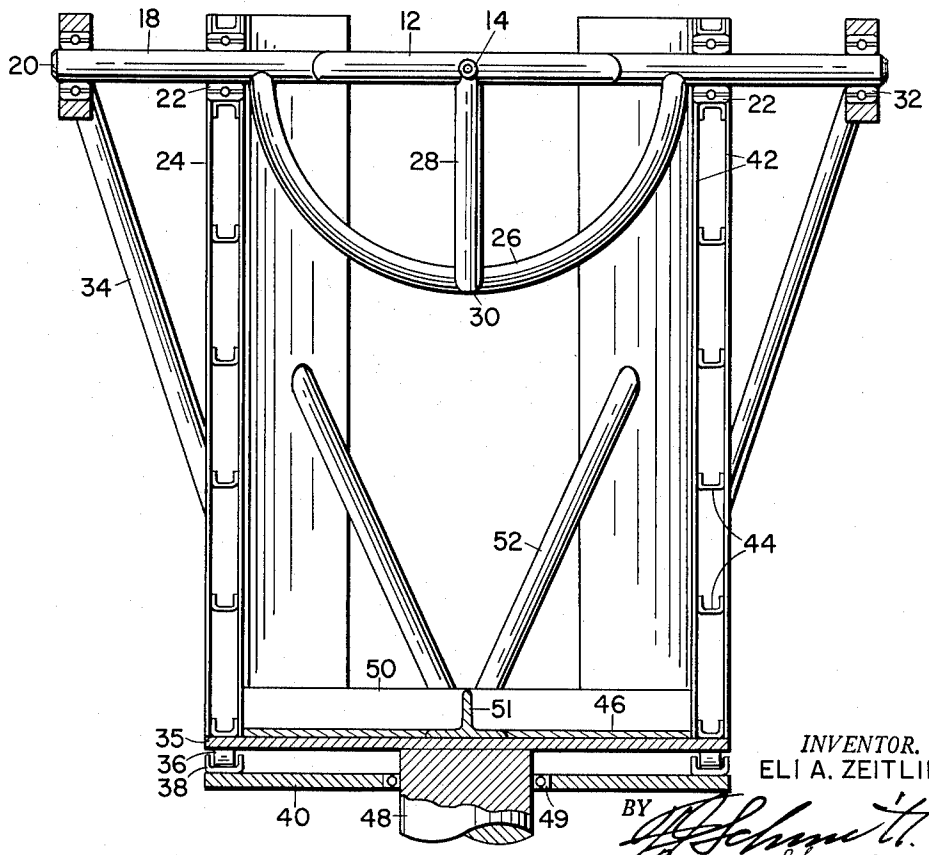


Fig. 3

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GIMBAL MOUNTING

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13 Claims. (Cl. 248—180)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefore.

This invention relates to gimbal mountings or supports, and is particularly concerned with novel structure providing a gimbal support system which allows free movement of a reaction means about any of three mutually perpendicular axes.

Gimbal support structures, especially for use in three dimensional flight simulation tables, are well known. The main criteria for gimbal support systems employed for the aforementioned purpose are rigidity of the structure and resistance to deflection and bending of the structural elements of the device during its operation, in order to obtain accurate readings from the instruments placed on the table.

Gimbal systems utilized in flight simulation tables in the past have, for example, employed dome structures supported and rotated by large sector gears, or a single yoke supported on a vertical shaft for rotation thereby. However, the prior art structures have not proven sufficiently rigid and resistant to deflection in operation to obtain satisfactory results, generally in the form of readings taken from instruments placed on the table. Thus, in the case of the above noted structure utilizing the large sector gears, the latter permit undesirable deflection and at the same time are difficult to manufacture accurately, while in regard to the devices employing the yoke structure, comparatively large deflections are produced in the elements comprising the yoke and in the vertical shaft serving as a support therefor. Other prior art gimbal structures have also proven unsatisfactory.

Accordingly, one object of this invention is to provide a highly rigid gimbal mounting resistant to deflection and bending of its component parts.

Another object is the provision of a gimbal system of the immediately foregoing type which is especially adapted for supporting a flight simulation table.

Yet another aim of the invention is to afford a gimbal support system which is rugged, easily constructed, inexpensive and is reliable in operation.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is an isometric view of a device according to the invention, with certain parts shown in section;

Fig. 2 is a plan view of the device of Fig. 1; and

Fig. 3 is a vertical section taken along line 3—3 of Fig. 2.

The gimbal mounting of the invention comprises briefly one or more cylindrically shaped supports of high rigidity in compression and in bending in all directions. Such supports are positioned on guide members located on a base, and are adapted to be rotated on these guide members by means of a centrally positioned power shaft rigidly connected to said supports. The reacting means

or table of the device is rotatably supported within a main ring in turn connected to a main ring shaft rotatably positioned on the supports. An auxiliary ring structure is associated with the main ring and main ring shaft for a particular purpose hereinafter pointed out. In addition to primary bearing members on said supports for rotatably supporting the main ring shaft, secondary bearing members are mounted on the supports outwardly of the primary bearing members for a purpose also set out below.

In Figures 1 to 3 of the drawing is shown a preferred embodiment of a highly rigid gimbal support system according to the invention, comprising a circular mounting table **10** concentrically positioned within a main ring **12** and mounted for rotation on oppositely aligned spindles **14** fixedly attached at one end thereof to opposite sides of the outer periphery of the table and having their other ends rotatably supported within suitable apertures **16** formed in the opposite sides of the circular periphery of said main ring. The axis of rotation of table **10** on spindles **14** is substantially in the plane of the table and passes through the center thereof. A main shaft **18** is fixedly connected to opposite sides of the outer periphery of main ring **12**, extending outwardly in opposite directions from such ring and being rotatably supported intermediate its outer ends **20** on a pair of opposed primary bearings **22** located near the top of two oppositely positioned support members or sectors **24** more fully described below. Main shaft **18** is positioned normal to the axis of spindles **14** in the plane of ring **12**, and the axis of such shaft passes through the centers of table **10** and ring **12**.

Two semi-circular auxiliary rings **26** and **28** are connected at right angles to each other at approximately their respective mid-portions, one of such rings **26** being connected to and extending vertically downward between opposite portions of main shaft **18** adjacent main ring **12**, and the other auxiliary ring **28** being connected to and extending vertically downward between opposite portions of main ring **12**. Rings **26** and **28** are suitably connected, as by welding, at their intersection **30**. These two rings serve to more efficiently transfer loads from the table **10** and main ring **12** to main shaft **18** and the primary bearings **22**, thus in effect functioning as stiffeners to reinforce the inherently flexible main ring **12** which is loaded normal to its plane of curvature.

The outer ends **20** of main shaft **18** are rotatably supported by a pair of secondary bearings **32** each mounted on a bracket **34** outwardly of primary bearings **22**, the brackets being respectively attached by suitable means, as by welding, to the outer sides of sectors **24**. Shaft **18** is held against axial displacement by suitable conventional means (not shown). The secondary bearings afford additional support for the main shaft **18**, and, the extension of such shaft to points beyond the primary bearings provides a continuous beam resting on four supports, including the secondary as well as the primary bearings, thus reducing deflection of the main shaft under table loads to a minimum. Also, the main shaft extensions and the associated secondary bearings have additional functions pointed out below.

Support sectors **24** which rotatably support main shaft **18** are cylindrically shaped and are each mounted at their base on a platform **35** for rotation by means of rollers **36** on guide members or tracks **38** circularly positioned on a base plate **40**. The vertically positioned support sectors are each constructed of a pair of spaced apart cylindrically shaped plates **42** held together by a number of vertically spaced horizontal stiffening or channel members **44** and a number of spaced apart vertical stiffeners **45** of a type similar to members **44**, such stiffeners being connected to adjacent plates **42** by any suitable means

such as by welding, by riveting, or the like. In this manner, reinforced support members **24** are provided for the loads transmitted thereto by the primary and secondary bearings **22** and **32**, respectively, which support members are highly resistant to deflection and have maximum rigidity.

Resting on horizontal platform **35** and connected perpendicularly to each other at their mid-portions is a pair of elongated members **46** and **47** having vertically positioned web or bracing elements **50** and **51** thereon, respectively, to increase the rigidity of such members. Member **46** is connected at its opposite ends to each of support sectors **24**. Elongated cross members **46** and **47** lend further stiffness to the assembly and to support sectors **24**. To prevent possible inclination or tipping of vertical support sectors **24** during operation of the device and to give additional support to these sectors, a pair of braces **52** are connected by suitable means between the intersecting portion of members **46** and **47**, and each of the support sectors, the braces extending upwardly at an angle from such members to the inner sides of the support sectors intermediate their ends. Integrally connected to platform **35** is a rotatable power shaft **48** axially positioned between the support sectors and extending downwardly through a bearing **49** in base plate **40**, such shaft being connected to a suitable drive means such as an electric motor.

Mounting table **10** may be employed for mounting any type of instrument, structure or component for testing its reaction to movement about three axes. Support sectors **24** can be rotated at various speeds, and during operation of the invention device, inertia and gyroscopic loads on the mounting table are transmitted by main ring **12**, auxiliary rings **28** and **26**, and main shaft **18** to primary bearings **22**. The auxiliary rings transfer loads from table **10** and ring **12** to shaft **18** chiefly in tension, a more efficient mode of load transfer than that which takes place in the absence of such auxiliary rings. The extension of main shaft **18** beyond primary bearings **22** and the utilization of secondary bearings **32** connected through brackets **34** to support sectors **24**, for supporting such extensions enables the support sectors through brackets **34** to supply a downward moment to the shaft extensions at the secondary bearings in opposition to the downward moment about the primary bearings supplied by the load on the table, thus further aiding in reducing deflection in main shaft **18** of the invention device and in furnishing a more positive means of aligning the table assembly than in prior art devices. Loads from the primary and secondary bearings are transmitted to support sectors **24**, and from these members are carried to the base plate **40** through rollers **36** and tracks **38**.

If desired, mounting table **10** may be of a shape other than circular, and rings **12**, **26** and **28** can likewise have a different configuration from the circular shape of the embodiment shown and described above, e. g. an elliptical curvature. In place of the support sectors **24**, a unitary tubular structure can be employed. The component parts of the invention device are preferably of metallic construction such as steel.

From the foregoing, it is seen that the invention provides a gimbal system especially adapted for use as a flight simulation table, and which is constructed in a manner affording maximum rigidity and minimum deflection of its component parts. The invention device is rugged, can be readily constructed from commercially available materials, is inexpensive and is reliable in operation.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A gimbal mounting which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, main ring means rotatably supporting said reacting means, auxiliary ring means associated with said main ring means, shaft means mounting said main ring means and said auxiliary ring means for rotation thereof, a base member, guide means positioned on said base member, support means mounted for rotation on said guide means, primary bearing means on said support means rotatably supporting said shaft means, and secondary bearing means mounted outwardly of said primary bearing means on brackets connected to said support means at a point horizontally below said primary bearing means to provide additional support for said shaft means and to reduce any deflection thereof.

2. A gimbal mounting which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, main ring means rotatably supporting said reacting means, auxiliary ring means associated with said main ring means, shaft means mounting said main ring means and said auxiliary ring means for rotation thereof, a base member, guide means positioned on said base member, cylindrically shaped support means mounted for rotation on said guide means, primary bearing means on said support means rotatably supporting said shaft means intermediate the ends thereof, and secondary bearing means mounted outwardly of said primary bearing means on brackets connected to said support means at a point horizontally below said primary bearing means to provide additional support for said shaft means near the ends thereof and to reduce any deflection of said shaft means.

3. A gimbal system as defined in claim 2, including a second shaft means connected to said support means for rotation thereof.

4. A gimbal mounting which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, a main ring rotatably supporting said reacting means, a main ring shaft extending outwardly from opposed portions of said main ring, at least two auxiliary rings connecting said main ring with said main ring shaft, a base member, guide means positioned on said base member, support means mounted for rotation on said guide means, primary bearing means on said support means rotatably supporting said main ring shaft, and secondary bearing means mounted outwardly of said primary bearing means on brackets connected to said support means at a point horizontally below said primary bearing means to provide additional support for said shaft means and to reduce any deflection thereof.

5. A gimbal mounting which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, main ring means rotatably supporting said reacting means, auxiliary ring means associated with said main ring means, shaft means mounting said main ring means and said auxiliary ring means for rotation thereof, a base member, guide means positioned on said base member, cylindrically shaped support sectors circularly mounted for rotation on said guide means, primary bearing means on said support sectors rotatably supporting said shaft means and intermediate the ends thereof, and secondary bearing means mounted outwardly of said primary bearing means on brackets connected to said support sectors at a point horizontally below said primary bearing means to provide additional support for said shaft means near the ends thereof and to reduce any deflection of said shaft means.

6. A gimbal support system which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, a main ring rotatably supporting said reacting means, a main ring shaft extending outwardly from opposed portions of said main ring, at least two auxiliary rings connecting said main ring with said main ring shaft to transfer loads in tension from said reacting means to said main ring shaft, a base

member, guide means positioned on said base member, cylindrically shaped support members mounted for rotation on said guide means, shaft means connected to said support members for rotation thereof, primary bearing members on said support members rotatably supporting said main ring shaft normal to the axis of said support members, and secondary bearing members mounted outwardly of said primary bearing members on brackets connected to said support members at a point horizontally below said primary bearing members to provide additional support for said main ring shaft to reduce any deflection thereof.

7. A gimbal support system which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, a main ring, said reacting means being mounted within said ring for rotation on an axis connected to opposite sides of the inner periphery of said ring, a main shaft normal to said axis extending outwardly from opposite sides of the outer periphery of said ring for rotatably supporting same, at least two auxiliary rings connecting said main ring with said main shaft to transfer loads in tension from said reacting means to said main shaft, a base member, guide means positioned on said base member, a cylindrically shaped support member mounted for rotation on said guide means, shaft means connected to said support member for rotation thereof, primary bearing members on said support member rotatably supporting said main shaft normal to the axis of said support member, and secondary bearing members mounted outwardly of said primary bearing members on brackets connected to said support member at a point horizontally below said primary bearing members to provide additional support for said main shaft to reduce any deflection thereof.

8. A gimbal support system which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, a main ring rotatably supporting said reacting means, a main ring shaft extending outwardly from opposed portions of said main ring, at least two auxiliary rings connecting said main ring with said main ring shaft to transfer loads in tension from said reacting means to said main ring shaft, a base member, a guide means positioned on said base member, a plurality of cylindrically shaped support sectors positioned normal to said base member and circularly mounted for rotation on said guide means, shaft means connected to said support sectors for rotation thereof, primary bearing members on said support sectors rotatably supporting said main ring shaft intermediate its ends normal to the axis of said support sectors, and secondary bearing members mounted outwardly of said primary bearing members on brackets connected to said support sectors at a point horizontally below said primary bearing members to provide additional support for said main ring shaft to reduce any deflection thereof.

9. A gimbal support system which comprises a reacting means supported for free movement about any of three mutually perpendicular axes, a main ring rotatably supporting said reacting means, a main ring shaft extending outwardly from opposed portions of said main ring, at least two auxiliary rings connecting said main ring with said main ring shaft to transfer loads in tension from said reacting means to said main ring shaft, a base member, guide means positioned on said base member, a pair of opposed cylindrically shaped support sectors positioned normal to said base member and circularly mounted for rotation on said guide members, a pair of opposed primary bearings near the top of each of said support sectors rotatably supporting said main ring shaft intermediate its ends normal to the axis of said support sectors, a pair of secondary bearings each mounted on a bracket outwardly of said primary bearings for additionally rotatably supporting said main ring shaft near the ends thereof to reduce any deflection of said shaft, said brackets being

respectively attached to the outer sides of said support sectors at a point horizontally below said primary bearings and a rotatable power shaft axially positioned between said support sectors and connected thereto for rotation thereof.

10. A highly rigid gimbal support system which comprises a reacting means, a main ring, said reacting means being mounted within said ring for rotation on an axis connected to opposite sides of the inner periphery of said ring, a main shaft normal to said axis extending from opposite sides of the outer periphery of said ring for rotatably supporting same, a pair of semi-circular auxiliary ring members adapted to transfer loads in tension from said reacting means to said main shaft, said auxiliary ring members being connected at right angles to each other, one of said ring members being connected to and extending downwardly between opposite portions of said main shaft and the other being connected to and extending downwardly between opposite portions of said main ring, a base member, guide members circularly positioned on said base member, a plurality of opposed cylindrically shaped support sectors circularly mounted for rotation on said guide members, a pair of opposed primary bearings on said support sectors rotatably supporting said main shaft intermediate its ends normal to the axis of said support sectors, a pair of secondary bearings each mounted on a bracket outwardly of said primary bearings for additionally rotatably supporting said main shaft near the ends thereof to reduce any deflection of said main shaft, said brackets being respectively attached to the outer sides of said support sectors at a point horizontally below said primary bearings, a rotatable power shaft axially positioned between said support sectors and extending through said base member, and a member connecting said support sectors with said power shaft for rotation thereby.

11. A highly rigid gimbal support system which comprises a mounting table, a main circular ring, said table being mounted within said ring for rotation on an axis in the plane of said table passing through the center thereof and connecting the outer periphery of said table with the inner periphery of said ring, a main shaft normal to said axis extending from opposite sides of the outer periphery of said ring for rotatably supporting same, a pair of semi-circular auxiliary ring members adapted to transfer loads in tension from said mounting table to said main shaft, said auxiliary ring members being connected at right angles to each other at their mid-portions, one of said ring members being connected to and extending downwardly between opposite portions of said main shaft and the other being connected to and extending downwardly between opposite portions of said main ring, a base member, guide members circularly positioned on said base member, a plurality of opposed cylindrically shaped support sectors positioned normal to said base member and circularly mounted for rotation on said guide members, a plurality of stiffening members connected to said support sectors, a pair of opposed primary bearings near the top of each of said support sectors rotatably supporting said main shaft intermediate its outer ends normal to the axis of said support sectors, a pair of secondary bearings each mounted on brackets outwardly of said primary bearings for additionally rotatably supporting said main shaft near the ends thereof to reduce any deflection of said main shaft, said brackets being respectively attached to the outer sides of said support sectors at a point horizontally below said primary bearings, a rotatable power shaft axially positioned between said support sectors and extending downwardly through said base member, and a platform member connecting said support sectors with said power shaft for rotation thereby.

12. A support system as defined in claim 11, including

a plurality of braces connected to said platform and extending upwardly therefrom to said support sectors.

13. A support system as defined in claim 11, wherein said stiffening members are composed of a plurality of spaced apart horizontal stiffening members and a plurality of spaced apart vertical stiffening members connected along the length and width of said support sectors.

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